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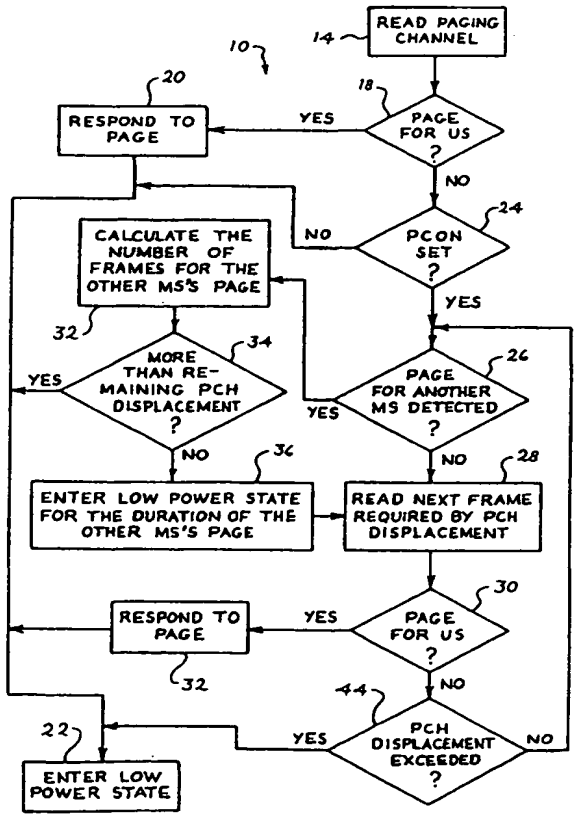
(54) Title: A METHOD OF INCREASING BATTERY LIFE IN MOBILE COMMUNICATIONS DEVICES WHICH USE PAGING CHANNEL DISPLACEMENT

(57) Abstract

A mobile communications device such as a pager or a cellular telephone enters a low power state more promptly than under TIA/EIA/IS-136 standards when an incoming message is pending for the device but is delayed by a first message broadcast for another such device. The device calculates the number of frames or SPACH slots required under those standards for the message for the other device; if that number is more than that reserved for the message for itself, then it powers down immediately until the next paging channel slot is to be received. If the number of frames or SPACH slots required for the message for itself, then the device powers down immediately only for the duration of the message for the other device.



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A METHOD OF INCREASING BATTERY LIFE IN MOBILE COMMUNICATIONS DEVICES WHICH USE PAGING CHANNEL DISPLACEMENT

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The present invention relates to mobile communications devices such as pagers and cellular telephones and to methods for increasing battery life, on any single charge, by reducing power draw by putting the device into standby operation sooner than IS-136 procedures otherwise call for.

2. RELATED ART

One of the main objectives of Industry Standard 136 of the Telecommunications Industry Association ("TIA") and the Electronic Industries Association ("EIA") is to improve battery savings in time division multiple access ("TDMA") mode digital mobile communications equipment, called "mobile stations". Battery savings is accomplished by reducing the time that the mobile station must read data among slots that are broadcast by a base station. Ideally, the mobile station needs to read, at full internal processing power, only one TDMA block of every 64 transmitted, thus for .02 second of each 1.28 second block, until it determines that a message is coming to it. See Fig. 2A. The device can "sleep" in a standby mode, at a low power state, for the remaining 1.26 seconds, or over 98.4% of the time, if no message is coming, yet be immediately ready to receive messages transmitted. If a paging frame class of greater than 1 is used by the base station, yet greater battery life is possible.

When more than five mobile stations require access simultaneously to messages from the base station, each mobile station must generally read more data of each TDMA block, draining its battery more quickly, if messages are not to be delayed in reaching the mobile station. Up to five mobile stations may use each TDMA block simultaneously without increasing battery drain in the mobile stations or delaying the sending of messages.

Paging Channel ("PCH") Displacement allows the base station to require each mobile station to read extra "SPACH" slots (SPACH is short for combined "Short message service", "Paging channel", and "Access response Channel" communications modes or types), or "frames", in the broadcast transmission in order to determine what portions of a broadcast to greater than five mobile stations are being directed to the particular station. The base station's Page Continuation ("PCON") bit, in the Paging Channel slot, is received and read at full internal power by the mobile station once in every 64 TDMA blocks. If so directed by the PCON bit in the PCH Displacement signal, the mobile station then will also read additional SPACH slots, also at full internal power. See Figs. 2B and 2C.

"Paging Channel Continuation" protocol is used to determine which SPACH slots or frames the mobile station should read in a broadcast transmission, i.e, those slots or frames that may be directed to it rather than to other mobile stations. The PCH continuation information is, by IS-136 standards, included in the first SPACH slot or frame in the series, if any (there usually are), in a message transmission, to direct the mobile station to the specific slots that it is to read. See Fig. 2C

For example, as explained in section 4.8 of IS-136.1 Rev A (July 1966), a full-rate digital communications channel for a mobile station may have a PCH subchannel corresponding to a super frame phase ("SFP") of 27. Even if the mobile station determines there is no message directed to it, and if page continuation is set to 1 and the paging channel displacement to 4, it will nonetheless read SFP slots 29 and 31 (= 27 + 4) in the primary superframe and also will read slots "n + 1" and "n + 3" in the next primary superframe, but receive no message for itself. See Figs. 2B and 2C. Then the mobile station enters its low power state until the next occurrence of its assigned PCH subchannel. Reading these additional four slots reduces power savings from 98.4% (63/64ths) to 92.2% (59/64ths), or increases power consumption by about 400% over the resting state.

SUMMARY OF THE INVENTION

The present invention reduces the time that a mobile station device must draw power at a high internal rate in order to read signals that it actually does not need to read other than to keep up with the signal chain from the base station. When the mobile station is awaiting a message of a certain frame length inside a given TDMA block, it needs to read only the first SPACH slot or frame after the paging channel and determine, if the message is not immediately for that station, the number of frames following for a different mobile station. If that number exceeds the frame length for the message being awaited for the station, then the station enters the low power state until the next paging channel signal, in the next TDMA block. If that number does not exceed the frame length for the message being awaited, then the

station enters the low power state just for the duration of the message for the other station.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block flow diagram of the power-saving logic of the present invention;

Figs. 2A, B, and C are time flow diagrams of operation of the known IS-136 system; and

Fig. 3 is a time flow diagram of operation of the IS-136 system using the invention.

THE PREFERRED EMBODIMENTS

The present invention decreases the battery draw of a mobile communications device or station, such as a pager or cellular telephone, by allowing the station to power down to a "sleep"mode during times that messages are being transmitted that contain no information for that station, particularly when message volumes from the central station are high.

In particular, Fig. 1 depicts the message processing and power states of a mobile communications device 10 made according to the invention, in flow chart form. In the TDMA ("Time Division Multiple Access") mode, the mobile device or station 10 first, at a high power level, reads a paging channel 12 (see also Fig. 2A), as at 14. The paging channel is one of 64 such channels, slots, or blocks 16 in the TDMA signal pattern, which has a repeating length of 1.28 seconds. If an incoming message from a base station (not shown) is determined at 18 to be for the particular mobile station 10, then station 10 will recognize that the page, for instance, is for it, and will

record the message and respond as at 20 before entering the low power "sleep" state, at 22, for the remaining duration of that TDMA block. A longer sleep state can be arranged by the base station if it sets a paging frame class ("PFC") greater than 1, as is known in the art.

If the page or other message broadcast is not immediately for station 10, station 10 examines the page continuation ("PCON") bit in the paging channel 12, as at 24, to determine if any part of the following message is for that station 10. If the PCON bit is not set, indicating that no message follows for that station, then station 10 enters the low power state, as shown, also as known in the prior art. If the PCON bit is found at 24 to be set, indicating that a message for station 10 does follow, then station 10 will examine the beginning of the first SPACH slot transmitted and determine first if the message is for it or for another mobile station, as at 26. If the message is for station 10, then the frames of the message designated for station 10 by the paging channel displacement are read as at 28 and 30 and then responded to as required, as at 32. The mobile station 10 then enters the low power state until the next timed paging channel occurrence. This system and operation also are known in the prior art.

If, however, a page for another mobile station is detected at 26, as shown in Fig. 3, according to the present invention the mobile station 10 reads the first part of the next SPACH slot in the broadcast transmission. It then determines, as at 32, the number of frames or slots in the message for the other station. If the number of frames or slots in the incoming message is determined, at 34, to be greater than that remaining for the paging channel displacement of the message for the mobile station

10, then the station enters the low power state until the time for the next paging channel transmission. If the number of frames or slots in the incoming message for the other station is not greater than the remaining paging channel displacement of the message for the mobile station 10, then station 10 enters the low power state only for the duration of the other station's message.

Thus in Fig. 3, for example, station 10 first reads the paging channel 12 at full power and finds the PCON bit set (steps 14, 18, and 24 in Fig. 1) and the paging channel displacement field set to four. The station 10 then is set to read all of the next four SPACH slots of data, under IS-136. However, according to the invention, station 10 reads only the first of the next four SPACH slots to determine the paging channel displacement of that and the subsequent slots, since a message is sent only in sequential slots. If station 10 detects, at 32 in Fig. 1 and in slot 38 of the transmission in Fig. 3, a five slot message 38, 40, 42 for a different mobile station, then rather than reading all those slots, or even the next three required by its own PCH displacement instruction, it goes immediately, within the .02 second duration of balance of the first SPACH slot, to a low power state -- since there can be no message for it there or in the remaining slots of that other message 38-42.

If, in this same example, station 10 detects in the first SPACH slot 38 a two-, three-, or four-slot message for another mobile station, then, according to the invention, station 10 will enter the low power state just for a corresponding number of slots, at 36 in Fig. 1. It then will power up and read the next slot required by its PCH displacement, at 28.

In the situation in which the station 10 has entered a low power state for the duration of another mobile station's page, at 36 in Fig. 1, and then emerges to read the next frame required by the PCH displacement at high power, at 28 in Fig. 1, if the next frame read as at 28 has no information for the station 10, then the station again determines, as at 44, whether the PCH displacement is exceeded by the message for the other station. If it is, then the station 10 enters the low power state 22 until the next paging channel is broadcast. If it is not, then decision point 26 is applied again to the message being broadcast.

Slight variations in the steps and devices used will not depart from the scope and spirit of the invention. All such variations as come within the scope of the appended claims come within the scope of this invention.

WE CLAIM AS OUR INVENTION:

1. A method for saving battery power in a first mobile communications device, wherein the device operates in a TDMA mode under TIA/EIA/IS-136 standards including paging channel displacement, the method comprising the steps:

reading the paging channel for the device and detecting the page continuation bit therein;

reading a SPACH slot as indicated for the paging channel displacement, detecting any message for another, second communications device, and determining its slot requirements;

comparing the slot requirement for the message for the first device and comparing that requirement to the slot requirement for the message for the second device and,

in the event that the slot requirement for the message for the second device exceeds the remaining paging channel displacement for the message for the first device, then entering a low power state until the next paging channel is to be read.

2. The method defined in claim 1, further comprising the steps:

in the event that the slot requirement for the message for the second device does not exceed the remaining paging channel displacement for the message for the first device, then entering a low power state for the duration of the message for the second device, and then

powering up to read the next frame required by the paging channel displacement.

3. A method for saving battery power in a first mobile communications device, wherein the device operates in a TDMA mode under TIA/EIA/IS-136 standards including paging channel displacement, the method comprising the steps:

in the event that a signal is received by the first device indicating that a deferred message for the first device will be sent shortly, but a message for another, second device is first detected, determining the number of SPACH frames required for the message for the second device and comparing it to the number of frames remaining in the paging channel displacement for the message to be sent to the first device;

in the event that the number of frames required for the message for the second device is greater than the remaining paging channel displacement, entering a low power state until a next paging channel transmission is to be read at higher power; and

in the event that the number of frames required for the message for the second device is not greater than the remaining paging channel displacement, entering a low power state for just said number of frames and then returning to the high power state to read the next frame required by the paging channel displacement.

4. A method for saving battery power in a digital mobile communications device, wherein the device operates in a TDMA mode under TIA/-EIA/IS-136 standards including paging channel displacement, the method comprising the steps:

reading at a first power level a paging channel slot in a broadcast signal that may be directed to the device;

if no page continuation bit directed to said device is detected in said slot and signal, then reducing the power level of said device to a second, lower power level until the next paging channel slot is to be read;

if a page continuation bit directed to said device is detected in said slot and signal, then determining from said bit the number of SPACH slots required for the full communication to be received;

reading at about the first power level such of the data in the next SPACH slot received as indicates whether the message is for the device or not;

if the message is not directed to the device,

determining the number of SPACH slots required for that message, and

comparing the number of SPACH slots indicated as required by the page continuation bit directed to the device and the number of SPACH slots being transmitted; and

if the number of slots required for the message for the device is exceeded by the number of slots being transmitted, then reducing the power level

of the device to said second level until the next paging channel slot is again to be read, or

if the number of slots required for the message for the device is not exceeded by the number of slots being transmitted, then reducing the power level of the device to said second level until transmission of the remaining SPACH slots for the current message for the other device is completed.

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Fig. 1

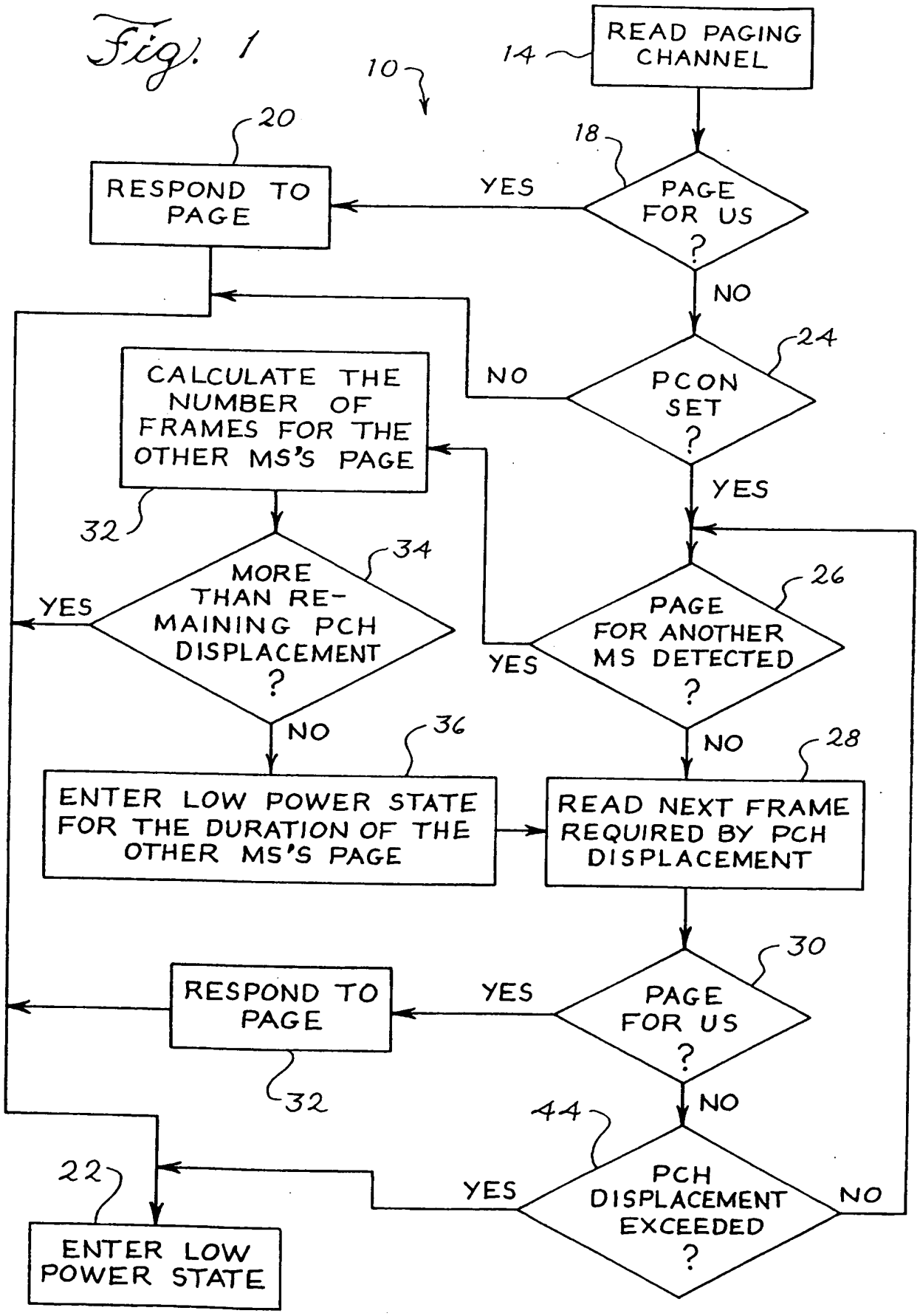
10
14
READ PAGING CHANNEL
18
PAGE FOR US ?
YES
20
RESPOND TO PAGE
NO
24
PCON SET ?
NO
CALCULATE THE NUMBER OF FRAMES FOR THE OTHER MS'S PAGE
32
YES
26
PAGE FOR ANOTHER MS DETECTED ?
YES
34
MORE THAN RE-MAINING PCH DISPLACEMENT ?
YES
NO
36
ENTER LOW POWER STATE FOR THE DURATION OF THE OTHER MS'S PAGE
NO
28
READ NEXT FRAME REQUIRED BY PCH DISPLACEMENT
30
PAGE FOR US ?
YES
RESPOND TO PAGE
32
NO
44
PCH DISPLACEMENT EXCEEDED ?
YES
NO
22
ENTER LOW POWER STATE

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Fig. 2A (PRIOR ART)

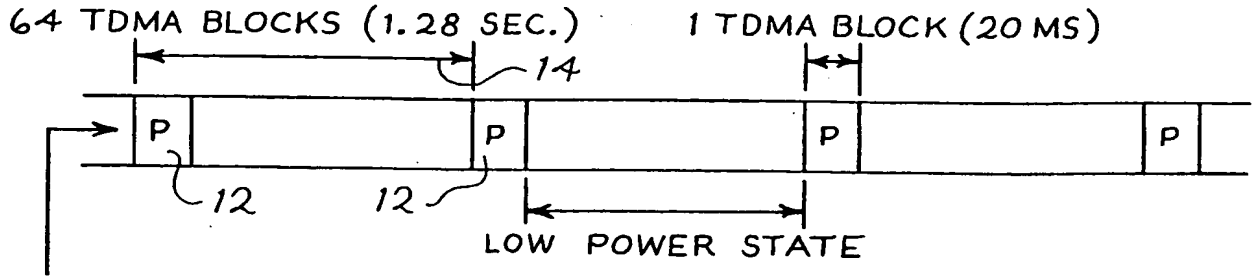

Fig. 2B (PRIOR ART)

PCH DISPLACEMENT

PRIMARY SF							SECONDARY SF		PRIMARY SF				
BCCH	SPACH		X		X		BCCH	SPACH	BCCH	SPACH			BCCH
						X					X	X	
SFP ... 27 28 29 30 31									n n+1 n+2 n+3 ...				

SPACH MESSAGE CONTINUATION (PCH)

PRIMARY SF							SECONDARY SF		PRIMARY SF				
BCCH	SPACH		X		X		BCCH	SPACH	BCCH	SPACH			BCCH
						X					X		
SFP ... 27 28 29 30 31									n n+1 n+2 n+3 ...				

Fig. 2C (PRIOR ART)

P → PAGING CHANNEL
S → EXTRA SPACH SLOTS REQUIRED FOR PCH DISPLACEMENT
A → SPACH SLOTS FOR ANOTHER MS

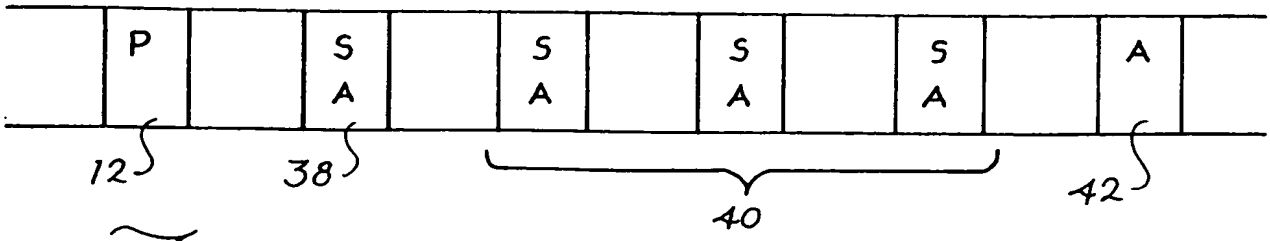

Fig. 3

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INTERNATIONAL SEARCH REPORT

Inte onal Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04Q7/38

According to International Patent Classification (IPC) or to both national classification and IPC

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 97 20446 A (ERICSSON GE MOBILE INC) 5 June 1997 see page 6, line 3 - page 7, line 18 see page 15, line 28 - page 17, line 6 see page 19, line 9 - page 21, line 22 see page 30, line 12 - page 31, line 27	1-4

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☒ Patent family members are listed in annex.

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